



Can MOOCs empower people to critically think about climate change? A learning outcome based comparison of two MOOCs

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ABSTRACT

Climate change can be regarded as one of the key topics of sustainable development where public awareness and education are crucial. In the field of education, Massive Online Open Courses (MOOCs) have raised remarkable attention throughout the last decade as their initial objective is to provide massive open online education for everyone. This article aims to explore the impact of MOOCs on learning about climate change. This is necessary in order to evaluate whether MOOCs can make a substantial contribution to lifelong learning about sustainable development for a wider audience. We therefore present findings from self-assessment questionnaires of participants from two climate change MOOCs provided by two-distance learning universities in Germany and Portugal. Both MOOCs aimed at imparting to the participants the competencies to better understand the topic of climate change. The objective of the survey was a competency-based evaluation to review which learning outcomes have been achieved. The results indicate that taking part in either of the MOOCs increased the participants' competencies to critically engage in the climate change debate. MOOCs are able to convey certain learning outcomes to the students and thus can contribute to climate change literacy. For further research, we recommend a more differentiated view on MOOCs and the learning opportunities for participants. Options for potential improvement are to think of better ways of how to integrate MOOCs into climate change education or to consider possibilities to increase the attractiveness of MOOCs for instance by using innovative formats to overcome the barriers between formal and informal learning.

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1. Introduction

Climate change is a key topic of sustainable development. Following the fifth report of the Intergovernmental Panel on Climate Change (IPCC), the future impacts of climate change, although in different degrees of severity, will affect societies all over the globe (IPCC, 2014). To prevent the most disastrous consequences of climate change, societies have to take a route towards more sustainable ways of living and economic growth. The prerequisite of a societal, economic and political shift towards sustainable development is public awareness (Borawska, 2017; Murphy, 2012). Alarming, studies about public awareness and public opinion about climate change are mixed at best. Even in the

run-up to high-level events in international climate politics such as the Climate Summit in Paris (2015) which are carefully observed by the media, public awareness is still moderate (Bakaki and Bernauer, 2016; Jamelske et al., 2013). This is dismaying as citizens' awareness serves as a precondition to formulate policy preferences and exert pressure on policymakers. Against this background, education is a key component to anchor the importance of climate change within societies. Only informed and educated citizens are in a position to exert pressure on policymakers and to elicit responses towards climate change protection from the local up to the global level. The vital role education can play in addressing the challenge of climate change is incrementally recognised (Mochizuki and Bryan, 2015). Climate change is one of the critical issues in the Roadmap of the Global Action Programme for Education for Sustainable Development (UNESCO, 2014). International educational policymakers and scholars stress the importance to increase climate literacy in people which means to support their acquisition of specific knowledge and

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skills to respond to climate change, such as critical thinking and systemic approaches for identifying interrelations of several topics/problems (Bangay and Blum, 2010; Burandt and Barth, 2010). Educational institutions have to ensure that the current state-of-the-art research is used to inform citizens and to contribute to their ability to understand and critically participate in public discussions about climate change. Active public participation is an important normative goal in formulating adequate responses to climate change (Few et al., 2007). However, this educational goal is puzzling as climate change can be characterised as a ‘super wicked problem’ that cannot be tackled by one single scientific discipline alone (Levin et al., 2012). Conveying an interdisciplinary perspective on climate change to citizens is a precondition to comprehensively understand all dimensions of the problem (Hulme, 2009). For instance, the politics of climate change cannot be captured without a basic understanding of the scientific background of climate change (Breitmeier and Otto, 2012). Moreover, a thorough understanding of climate change and climate politics is not possible without the discussion of the multi-faceted issues of climate justice (questions of inter- and intragenerational justice, moral aspects of policy instrument choice etc.). Roser et al. (2015) underline that an interdisciplinary dialogue on climate change only involving the natural and social sciences is insufficient and calls for the integration of normative insights which have been examined and debated in the field of climate justice, or climate ethics.

For broadening participation and to reach a critical mass for this form of interdisciplinary education, higher education has to devote attention to open and flexible ways of learning (Teixeira et al., 2012). In the latest discussion about open education, Massive Open Online Courses (MOOC) have raised remarkable attention inside and outside the academic debate as they come along with the promise to open up education for everyone (Liyanagunawardena et al., 2013). The term MOOC was coined by Dave Cormier in 2008, starting his course about Connectivism and Connective Knowledge at the University of Prince Edward Island. Since then, MOOCs have had significant educational ramifications (Fischer, 2014). At the peak of the elation, the New York Times called 2012 the “year of the MOOC”; since then, the debate has become more pertinent and to some extent disenchanting (Pappano, 2012). On the one hand, MOOCs have been acclaimed for their potential to educate a much wider audience about core issues of our times than classical university teaching could ever accomplish. On the other hand, MOOCs have been exposed to criticism from various corners. Didactically, they have been criticised for missing an appropriate didactical concept to spur interaction among students (Baggaley, 2014, 2013; Otto et al., 2018). The high dropout rates of participants have been identified as another major deficit of MOOCs (Diver and Martinez, 2015; Jordan, 2015; Liyanagunawardena et al., 2014). MOOCs attract massive amounts of students to enrol for the courses, but all big MOOC providers suffer from completion rates under 10 per cent (Diver and Martinez, 2015). Notwithstanding that the current research focus is on how to reduce dropouts in MOOCs, we find that a more cardinal research gap in terms of open educational tools, like MOOCs, is their effectiveness in promoting the quality and attractiveness of education for topics of paramount importance such as sustainable development.

Hence, this paper aims to evaluate the contribution of MOOCs as an educational tool for lifelong learning about climate change. Starting from an interdisciplinary perspective, two MOOC case studies were analysed that shared the objective to impart to the participants the competencies to better understand the topic of climate change with a specific focus on the related issue of climate justice. Both MOOCs were didactically designed to enhance the participants’ ability to think and reflect critically about climate

change, climate change politics and climate justice in order to empower them to engage critically in climate change and climate justice debates and to be critical observers of the climate conference in Paris (2015). Whether MOOCs can be regarded as an educational tool for climate change is the subject of this case studies analysis. After the MOOCs were carried out, a questionnaire survey was conducted with the participants that successfully finished the courses. To amplify the analysis, the survey was competency-based and intended to review whether the learning objectives had been achieved and to unravel the veil around our target group.

The article is structured as follows: The first section presents the design and objective of both MOOCs. The second section discusses how the survey was conducted and evaluated. In section three, the results regarding our research question are presented and analysed. In the last section, the added value of our findings for the broader discussion about open education and climate change are outlined.

2. Methods

This section presents the case studies and the methods used for a competency-based evaluation of learning outcomes (Saunders et al., 2007). For this purpose, self-assessment questionnaires were used. Both MOOCs were targeting participants from all kinds of disciplines and were aimed at teaching participants the basic competencies to understand climate change and to critically follow the upcoming climate change conference in Paris (2015). Albeit both MOOCs shared this common learning objective, they differed in how they approached the topic.

2.1. Case studies

2.1.1. FernUniversität in Hagen: MOOC “climate change – A question of justice”

The FernUniversität in Hagen (FernUniversität) is the biggest university in Germany with more than 76.000 students. The FernUniversität is the only state-maintained distance teaching university in the German-speaking countries and regions. Teachers and contact persons for the students are to be found on the main campus at Hagen as well as at the around 30 study centres in Germany, Austria and Central and Eastern Europe. Offering high-quality degrees (Bachelor, Master and Doctorate), the FernUniversität uses the latest distance education system combined with a blended learning approach. The MOOC “Climate Change – A question of justice” was carried out in cooperation with Lund University in Sweden. The goal of the MOOC was to increase the participants’ ability to understand the political spin behind the ostensible informal answers commonly voiced by the international community in the field of climate change. To achieve this, the MOOC adopted an interdisciplinary perspective by inviting international experts from different fields to give short lectures on pressing topics in the field of climate change. The lectures were held by scholars coming from a broad range of universities (for instance, University of Sussex, Stockholm University or Brown University), academic research institutions (such as the Potsdam Institute for climate impact research) and non-governmental organisations (such as Greenpeace International or the Health of Mother Earth Foundation). The lectures dealt with topics as diverse as the science of climate change, climate governance, the economics of climate change or the impacts of climate change on nature and humanity. To illustrate this wide range of topics, the experts discussed important issues such as climate wars, poverty and inequality or the role of metropolitan regions in a changing climate.

The MOOC was designed as an xMOOC which refers to the

pedagogical design predominantly used by all big MOOC providers like Coursera or edX (Otto, 2018). xMOOCs are based on an instructional design which echoes traditional university course structures, containing classical teaching resources like video lectures, e-learning platforms including quizzes and badges awarded to the students at the end of the course.

The MOOC was running from the beginning of September 2015 until the start of the United Nations Climate Change Conference in Paris at the end of November 2015. The MOOC consisted of eight units with four to five video lectures, each being approximately ten minutes long. Additionally, a virtual forum was provided for each unit and a tutor supervised the discussions in the forums. In a weekly live-chat, the lecturers commented on the forum discussions and gave further up-to-date information. Furthermore, additional material was made available to the participants (e.g. access to a selection of articles from the journal WIREs Climate Change). In order to test their understanding of the units, participants had the possibility to take a short multiple-choice quiz each week. To acquire a certificate at the end of the MOOC, participants had to watch at least 80 per cent of the lectures and to pass the quizzes for each unit with a success rate of at least 80 per cent. Table 1 gives an overview of the topics and contents of the MOOC.

Overall, 2908 students participated in the MOOC “Climate Change – A question of justice”, 302 of them earning a certificate at the end of the course – a completion rate of around 11 per cent. The participants represented 78 countries mainly from Europe and North America but, to a lesser extent, also from Africa, Asia and South America.

2.1.2. Universidade Aberta: MOOC “the lived experience of climate change”

Established in 1988, Universidade Aberta (UAb) is the dedicated distance learning public higher education (HE) institution in

Portugal. All pedagogical provision from UAb is taught using eLearning since 2008. UAb is a reference in European higher education institutions in the area of online and advanced e-learning, using the most advanced information and communication technologies, and a recognised Virtual Pedagogical Model (Pereira et al., 2008). UAb also developed an appropriate pedagogical model for MOOCs (the iMOOC Model; Coelho et al., 2015).

The MOOC “Climate Change: the context of life experiences” (designed according to the iMOOC model) aimed to introduce the concept of climate change in the context of sustainable development, relating it to each individual's life experience, such as adaptation and mitigation of climate change effects, e.g. floods, water shortages, increase of sea level, coastal erosion, and changes of biodiversity. The course also aimed to help to comprehend and critically analyse the information on climate change emanated from a variety of organisations, from a diversity of perspectives, including its scientific, political, economic, and social perspective. The course had 4 iterations: (1) May 6th until July 1st, 2013 (8 weeks); (2) October 23rd until December 7th, 2014 (6 weeks); (3) May 18th until June 30th, 2015 (6 weeks); (4) October 26th until December 8th, 2015 (6 weeks). The first iteration of the MOOC was evaluated by Coelho et al. (2015).

The pedagogical model for MOOCs at UAb (iMOOC) applies the main pedagogical principles of the institutional virtual eLearning pedagogical model, built upon four main pillars: learner-centeredness, flexibility (time and space), interaction, and digital inclusion (Pereira et al., 2008). The iMOOC approach intends to combine autonomous and self-directed learning with a strong social dimension and tries to articulate the flexibility that distance online learners need with the pacing necessary to help them get things done and avoid the constant postponing of the learning activities (Teixeira and Mota, 2014).

In the iMOOC courses, registration is required only for

Table 1
Overview of topics and related contents in the MOOC at FernUniversität.

Topic	Contents
(Unit 1) The Science of Climate Change (1 week)	<ul style="list-style-type: none"> ● The Science of Climate Change Sea Level Rise - Are we pulling the plug from Antarctica? Adaptation to climate change: options and uncertainties
(Unit 2) International climate governance: Understanding the deadlock (1 week)	<ul style="list-style-type: none"> ● The history of the international climate negotiations The actor coalitions and their positions Lessons from international relations theories ● What's at stake in Paris? ● What's wrong with climate finance?
(Unit 3) Transnational climate governance: leading the way? (1 week)	<ul style="list-style-type: none"> ● The institutional architecture of global climate politics: Regime complex or institutional fragmentation? ● The democratic legitimacy and influence of non-state actors in global climate governance ● Climate discourses and power in the post-Copenhagen climate diplomacy ● Just transitions? Reconciling climate and energy justice
(Unit 4) Carbon markets (1 week)	<ul style="list-style-type: none"> ● The basics of carbon markets: an overview of carbon markets around the world ● Why carbon markets raise such important questions of justice ● The EU Emissions Trading System (EU ETS) ● System: how should and does it work? How can it be improved? ● Carbon conduct: Shaping the low carbon self
(Unit 5) North-South relations and eco-colonialism (1 week)	<ul style="list-style-type: none"> ● Climate justice ● The Clean Development Mechanism – The theory, the practice, need for reform ● The case study of agrofuels and land-grabbing ● Climate change impacts and poverty: The vulnerability of the poor
(Unit 6) Climate refugees, climate wars and geopolitics (1 week)	<ul style="list-style-type: none"> ● Migration and climate change in Africa ● A critique of climate security discourses ● Climate change and violent conflict: what do we know? ● Energy security, geopolitics and the future of renewable energies
(Unit 7) Solutions I: Unburnable carbon and renewable energies (1 week)	<ul style="list-style-type: none"> ● Unburnable carbon and divestment (interview) ● The great transformation ● Rebuilding after disaster ● What can the world learn from the German “Energiewende” (energy transition)? Is there hope from markets for renewable energy?
(Unit 8) Solutions II: Degrowth and climate justice (1 week)	<ul style="list-style-type: none"> ● Degrowth or green growth? ● Why changing lifestyles is so difficult ● The role of cities in a changing climate ● Leave the oil in the soil: the social and environmental costs of oil extraction in Nigeria

Table 2

Overview of topics and related contents in the MOOC at UAb.

Topic	Content
(Unit 1) Introduction. What does science tell us about climate change? (2 weeks)	<ul style="list-style-type: none"> ● The Earth's climate system: its fundamental components, external factors/drivers of the system; ● mechanisms of climate change; ● modelling and climate simulations; ● climate history; ● prediction of future climate change;
(Unit 2) Economics and climate change (1 week)	<ul style="list-style-type: none"> ● the conventional approach of neoclassical economics when applied to climate change, and the key concepts of innovation and market failures; ● cost-benefit analysis associated with interventions related to climate change; ● alternative approaches to global economics of climate change,
(Unit 3) Policy on climate change: a perspective of political science (1 week)	<ul style="list-style-type: none"> ● climate change in political science and on the political agenda; ● key actors at national and international level in the debate on climate change and identification of their interests and goals in the entire political process; ● major international conferences, protocols, mechanisms, targets and negotiable agreements on climate change; ● difficulties and conflicts of the whole process for obtaining an effective policy for global climate change agreement.
(Unit 4) The sociological perspective on climate change (1 week)	<ul style="list-style-type: none"> ● climate change as a social construction; ● "individual action" and "social structure" in addressing the issues and actions associated with climate change; ● the growing importance of sociology in addressing the issues of climate change.
(Unit 5) Climate change: integration of perspective in the context of sustainable development (1 week)	<ul style="list-style-type: none"> ● simulation models that assess and predict, the causes, effects and possible solutions to combat climate change; ● integration of the problematic of climate change and interconnection between the different scales of analysis and the overlap and relationship between the different approaches and interdisciplinary perspectives.

publishing in the institutional spaces but all content is open access, i.e. anyone can read it. Resources provided are licensed as Open Educational Resources or freely available on the Internet. Content produced by participants is licensed according to the individual preference of the authors. Learning is learner-centred and based on the realization of activities. It should be evidenced through the creation of digital artefacts published online. The learning process combines autonomous self-study and reflection with interaction with other participants in an open social context. Participants are expected to take an active role in and be responsible for their own learning, but also to actively engage in helping to build a supportive learning community (Teixeira and Mota, 2014).

The iMOOC course was run on a virtual eLearning platform. A "boot camp" e-learning module (3 days) initiated all MOOC iterations and was meant for participants to get acquainted with the virtual space, tools and platform functionalities, as well as with the learning process and the communication in the course.

The course was structured in 5 sequential topics (see Table 2). To ensure instructional quality (Margaryan et al., 2014), several strategies were applied, including: (i) introductory short videos (up to 5 min each) to each topic presented by the course teachers, (ii) summary of suggested activities and a document with detailed guidelines for their development, as well as learning materials, (iii) discussion *fora* for each topic where participants interacted, (iv) weekly feedback by the teachers which was drawn upon the tutors' synthesis of subjects and debates on the *fora* and on blog messages of the participants.

Overall, over 1500 students¹ enrolled in the MOOC "Climate Change: the context of life experiences" in the editions of 2013 and 2014, 50 of them earning a certificate at the end of the course – a completion rate of approximately 3 per cent. The enrolled participants were mainly Portuguese and from Portuguese speaking countries, i.e. from Europe, South America and Africa.

¹ The exact number of enrolment cannot be completely verified due to specific technological system characteristics. The indicated number is a reliable estimation. Any registrations or counts of platform entries from non-participants, like teaching and technical support staff, was deleted.

2.2. Questionnaire-based data collection and analysis

To examine whether the students acquired the intended learning outcomes and competencies, a joint online questionnaire was sent to the students at the end of the MOOCs. Since both MOOCs shared the main learning objectives, using a common questionnaire allows for identifying differences and similarities concerning the learning experience of the students. Furthermore, as both MOOCs were open for everyone interested in the topic, the questionnaire was designed to identify the actual audience of the MOOCs and was sent only to participants that finished the course and earned a participation certificate. The questionnaire was developed in Google Docs forms, disseminated by e-mail, and the answers were anonymous. The questionnaire was pre-tested with a sample of 5 university students, non-participating in either of the MOOCs.

The questionnaire contained general questions concerning age, the highest level of education, the previous (self-assessed) knowledge about climate change or the reason(s) for enrolment. The subsequent questions were designed to investigate whether the participants acquired the intended learning objectives and competencies such as: (i) enhancement of the level of knowledge about climate change, including scientific background, mitigation and adaptation measures, governance, prevention solutions and justice; (ii) competencies for participating critically in climate change debates, including discussions in the media, explaining to others how climate change and social justice are closely interlinked, and engaging in debates about climate change with persons from different backgrounds; (iii) level of satisfaction with the course and outlook on further engagement in the climate change debate. Table 3 shows how the questionnaire was linked to the content and activities of the MOOC.

A Likert scale was used with 5 levels (from "no knowledge" to "excellent knowledge" or "fully agree" to "fully disagree"). The 5 level scale was applied since it is the most commonly used scale for the purpose of questionnaires (Saunders et al., 2007). Besides descriptive statistics, Spearman's rank correlation coefficient (Spearman's rho) was applied to elicit promising patterns in the

Table 3
MOOC content and related items of the questionnaire.

MOOC content and activities	Related items of the questionnaire
Unit 1 (FernUniversität): The science of climate change Unit 1 (UAb): Introduction. What does science tell us about climate change?	I feel the course has enhanced my level of knowledge about ... ● the scientific background of climate change ● responses to climate change in terms of mitigation and adaptation ● I feel the course has enhanced my level of knowledge about climate change as a problem of governance at all levels
Unit 2 (FernUniversität): International climate governance: Understanding the deadlock Unit 3 (UAb): Policy on climate change: a perspective of political science	
Unit 3 (FernUniversität): Transnational climate governance: leading the way? Unit 2 (UAb): Economics and climate change Unit 3 (UAb): Policy on climate change: a perspective of political science	● After having completed the course, I am able to critically scrutinize the discussion about climate change in the media
Unit 4 (FernUniversität): Carbon Markets Unit 2 (UAb): Economics and climate change Unit 3 (UAb): Policy on climate change: a perspective of political science	I feel the course has enhanced my level of knowledge about ● climate change as a problem of governance at all levels ● the different solutions discussed to prevent the effect of climate change
Unit 5 (FernUniversität): North-South relations and eco-colonialism Unit 6 (FernUniversität): Climate refugees, climate wars and geopolitics Unit 5 (UAb): The sociological perspective of climate changes Unit 7 (FernUniversität): Solutions I: Unburnable carbon and renewable energies Unit 8 (FernUniversität): Solutions II: Degrowth and climate justice Unit 5 (UAb): Perspectives integration within sustainable development Moderated forums (FernUniversität and UAb)	● I feel the course has enhanced my level of knowledge about climate change as a question of justice ● I feel the course has enhanced my level of knowledge about climate change as a question of justice ● I feel the course has enhanced my level of knowledge about the different solutions discussed to prevent the effect of climate change After having completed the course, I am able to ... ● critically scrutinize the discussion about climate change in the media ● explain to others how climate change and social justice are closely interlinked ● to engage in debates about climate change with persons from different backgrounds

data. Spearman's rho was adopted as it allows measuring non-parametric data and because our data contains ranks and ordinal scales. In contrast to Pearson's correlation, it does not posit the assumption that the relationship between the variables is linear nor posits that the variables have to be measured on interval scales (Hauke and Kosowski, 2011). Moreover, Spearman's rho is robust to outliers (Hryniewicz, 2014). The results in each question were characterised using the scores' average, taking into account the statistical assumptions defined by Tullis and Albert (2013) when using Likert scales i.e. (i) the distances between scale levels are equivalent, (ii) the scale adopted expresses the object of study, and (iii) the ordinal scale has at least five response options. The Statistical Package for the Social Sciences (SPSS) software was used to analyse the collected data.

The questionnaires were sent to all MOOC participants who completed the course (of both case studies) in December of 2015. For the FernUniversität case study, 303 participants received the questionnaire and 170 participants completed it (response rate 56%). Also, a number of 21 participants responded partially to the questionnaire (the variance in the number of answered questions from FernUniversität explains the variance in the numbers that appear in the different tables in the results section). UAb sent the questionnaire to 50 participants and received 35 fully completed questionnaires (response rate 70%).

The limitations associated with questionnaires, e.g. validity, reliability and generalizability, such as those associated with response bias (Saunders et al., 2007) were taken into account in the discussion of results, and when drawing conclusions.

3. Results

As a first observation, the survey reveals that the participants of the two MOOCs were 43% (UAb) and 59% (FernUniversität) female

and 57% (UAb) and 41% (FernUniversität) male, and that the FernUniversität-MOOC about climate justice attracted a younger target group (mainly between 20 and 40 years) than the MOOC from UAb (mainly between 30 and 50 years).

Differences were also detected with regards to the students' level of education (Fig. 1). Whereas the FernUniversität-MOOC predominantly attracted Master students, almost exclusively Bachelor students enrolled in the UAb-MOOC. Albeit the FernUniversität-MOOC was not offered exclusively for Master students, the provider of the MOOC is an interdisciplinary study programme for Master students. This fact might have suggested that the MOOC was designed for a Master's level and thus predominantly inspired this group to enrol for the MOOC.

In the case of UAb, the course was disseminated in all institutional communication channels and in a specific television programme, having reached thereby a broad audience from diverse

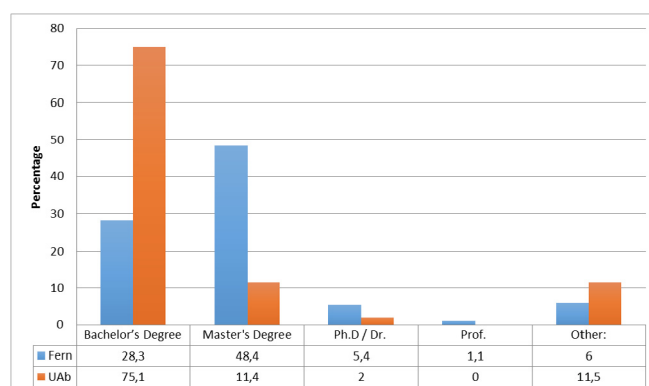


Fig. 1. Participants' profile regarding their highest level of education.

education levels, but eventually with a predominance of persons who were completing their first degree. Furthermore, bachelor students are the largest group of students at UAb, and several (interdisciplinary) undergraduate programmes are offered in environmental and social sciences.

The students of both MOOCs self-assessed their previous knowledge about climate change as moderately high (Fig. 2). The scale extends from 1 meaning ‘no knowledge’ to 5 equivalents to ‘excellent knowledge’. The participants of both MOOCs perceived their previous knowledge on climate change similarly, as average (“3”; ca. 44%) or good (“4”; ca. 31%). Only a slight percentage of the participants (FernUniversität 4,1% UAb 2,8%) indicated to have no prior knowledge about climate change.

These high rates of perceived pre-knowledge support the assumption that the students of both MOOCs had delved into the topic of climate change before. Hence, there appears to be no compelling reason to argue that the MOOCs attracted a substantial amount of interested laypeople to engage with climate change for the first time. One cause for the low participation rate of laypeople might be the channels used to advertise the MOOCs. Newsletters, journals, forums and the social media channels used to promote the MOOCs predominantly addressed an academic audience, in particular, those whose profession or education is connected to environmental or social issues, with links to climate change. Nevertheless, the field of academic background of the participants was not inquired to confirm this analysis, which should be addressed in future studies. On the other hand, a few channels were used to reach a broader audience. For instance, FernUniversität hosted a video on YouTube to invite participants to enrol for the MOOC. In total, the video was viewed 5.365 times.

Despite the low participation rate of laypeople (about 17%), there is backing in the data to suggest that taking part in the MOOCs leads to knowledge increase, as over 90 per cent of the students from both courses “fully agreed” or “rather agreed” to the statement that the course had enhanced their level of knowledge about climate change (Fig. 3).

Using Spearman’s rho (correlation is significant at the 0,01 level) to examine the relation between “education level” and “self-perception of knowledge assessment” (0,266**) as well as “self-perception of knowledge enhancement” (0,185**), a weak but significant correlation has been observed, (Table 4), suggesting that a higher level of education is a) linked to a broader previous knowledge on climate change and b) is linked to further knowledge gains through the participation in the MOOC. This analysis also indicated that the level of participants’ “self-perception of knowledge assessment” prior to the MOOC participation was correlated with their level of “self-perception of knowledge enhancement”; this result might indicate that the MOOCs contents’ were less adapted to a lay level of knowledge on climate change.

In addition to raising the general awareness of climate change, both MOOCs were intended to impart to the participants customised knowledge and competencies to engage in the public discourse

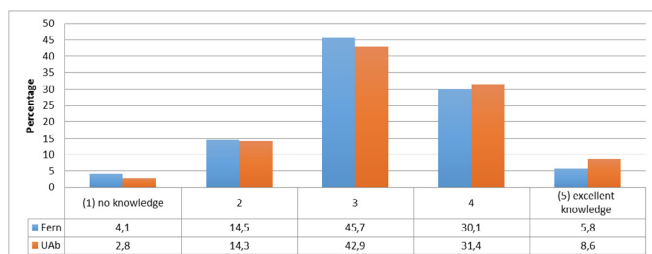


Fig. 2. Self-assessment of knowledge on climate change issues prior to the MOOC.

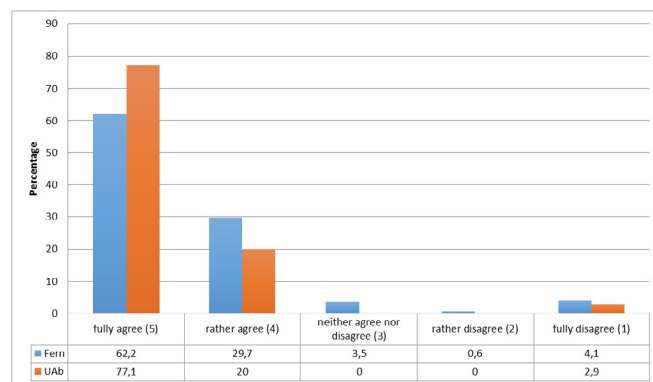


Fig. 3. Self-assessment of knowledge enhancement on climate change with the MOOC.

about climate change. In particular, the aim was to reconcile the different scientific disciplines dealing with climate change research. Explaining how each of the disciplines explores climate change and unveiling their interrelatedness can contribute to a holistic understanding. In both MOOCs, this holistic understanding encompassed the natural sciences base of climate change, structures of climate governance, mitigation and adaptation as well as possible solutions to deal with climate change. Moreover, the MOOCs were intended to convey the rather normative but salient message that climate change is a matter of social justice (emphasized in particular in the FernUniversität case, but included as well in UAb). Our choice to point out the dimension of justice in the MOOCs is based on a bulk of literature emphasising the link between climate change issues and questions of justice (Audet, 2013; Dunlop, 2013; Lyster, 2017; Minguet, 2018; Okereke, 2010; Routledge et al., 2018).

All fields of knowledge which the lecturers presented in the different curricular units were queried in the questionnaire. The students were asked in form of self-assessment whether taking part in the MOOC had enhanced their knowledge in the areas presented in Table 5.

The data of the assessment confirmed that there is considerable similarity among the students in all five areas in terms of their perceived knowledge enhancement. Predominantly, the answers are in a range between “fully agree” and “rather agree”. Differences appeared to occur for the FernUniversität-MOOC mainly regarding the scientific background of climate change (mean value 4,23). This might be explained by the fact that the FernUniversität-MOOC only dedicated one unit (out of eight, compared to out of five in the case of UAb) to the natural sciences base of climate change and did not go deeply into the details. Eventually, the knowledge enhancement for already well-informed participants was thus rather low. Salient and noteworthy, both MOOCs managed to convey the core message to the students that climate change is a question of social justice. This message was elucidated in almost all lectures and study materials and had the highest mean for FernUniversität (mean value 4,66) and the second highest mean for UAb (mean value 4,63).

The participants were conveyed central competencies to critically participate in climate change debates. Three core competencies were identified as a precondition for personal engagement. First, students should be enabled to critically scrutinize the discussion about climate change in the media. Second, they should not only be able to understand but *explain* to other people the interrelatedness of diverse perspectives, including the interconnectedness of social justice and climate change. Third, the interdisciplinary background of the MOOCs should empower the participant to engage in climate change debates with persons from

Table 4
Correlation analysis using Spearman's rho for questions related to the level of education, the perception of pre-knowledge assessment of climate change and the perception of knowledge enhancement after the course.

			Education	Knowledge assessment	Knowledge enhancement
Spearman's rho	Education	Correlation Coefficient	1,000	,266 ^a	,185 ^a
		Sig. (2-tailed)	.	,000	,006
		N ^c	232	217	218
	Knowledge assessment	Correlation Coefficient	,266 ^a	1,000	,155 ^b
		Sig. (2-tailed)	,000	.	,022
		N	217	217	216
	Knowledge enhancement	Correlation Coefficient	,185 ^a	,155 ^b	1,000
		Sig. (2-tailed)	,006	,022	.
		N	218	216	218

^a Correlation is significant at the 0,01 level (2-tailed).

^b Correlation is significant at the 0,05 level (2-tailed).

^c N refers to the number of observations that were correlated.

Table 5
Perception of self-assessment whether participating in the MOOC has enhanced knowledge on climate change.

The scientific background of climate change	Fern	UAb
Mean	4.23	4.6
Fully agree (5)	39	50
rather agree (4)	41	40
neither agree nor disagree (3)	14	0
rather disagree (2)	5	0
Fully disagree (1)	1	0
Responses to climate change in terms of mitigation and adaptation	Fern	UAb
Mean	4.46	4.59
Fully agree (5)	46	39
rather agree (4)	46	41
neither agree nor disagree (3)	5	0
rather disagree (2)	2	0
Fully disagree (1)	1	0
Climate change as a problem of governance at all levels	Fern	UAb
Mean	4.53	4.74
Fully agree (5)	51	74
rather agree (4)	42	26
neither agree nor disagree (3)	5	0
rather disagree (2)	1	0
Fully disagree (1)	1	0
The different solutions discussed to prevent the effect of climate change	Fern	UAb
Mean	4.35	4.5
Fully agree (5)	39	53
rather agree (4)	48	44
neither agree nor disagree (3)	9	44
rather disagree (2)	3	0
Fully disagree (1)	1	0
Climate change as a question of justice	Fern	UAb
Mean	4.66	4.63
Fully agree (5)	63	66
rather agree (4)	28	31
neither agree nor disagree (3)	5	3
rather disagree (2)	1	0
Fully disagree (1)	1	0

different backgrounds. The results of the applied questionnaire provided considerable evidence that taking part in either of the MOOCs increased the participants' self-assessed competencies in all three dimensions (Table 6). Furthermore, no significant differences could be observed concerning the core competencies between the MOOCs. Again, the ability to explain to others how climate change and social justice are closely interlinked received the highest approval in the rating (mean values respectively for FernUniversität 4,53 and UAb 4,62).

Table 7 shows the high satisfaction rate of participants in both MOOCs. Over 90 per cent of the participants either "fully agree" or "rather agree" with joining another MOOC, or recommending the course to others, and further engaging with the topic of climate change in the future.

4. Discussion

In this research, the guiding question was whether MOOCs are a promising tool for open education on climate change literacy. As the results presented are in many ways ambiguous, the answer to that question is inevitably twofold. On the basis of the evidence deduced from the self-assessment of participants' learning outcomes in the questionnaires, it seems reasonable to claim that the

participants of both MOOCs ameliorated their knowledge about climate change. These results might potentially be biased by the fact that all respondents of the questionnaire finished the course activities with success, namely the quizzes in case of FernUniversität and the assignments in case of UAb, which implies study and reflection of the subject. However, referring to the questionnaires, the perception of increased knowledge is observed in all thematic fields for both MOOCs. As shown in Tables 1 and 2, climate justice was the cross-sectional and overarching topic in both MOOCs. This is explicitly and implicitly visible in all of the different units. Addressing climate justice in both MOOCs was based on the dominant view in the literature that, regardless which field of climate change is investigated (e.g. politics, economics, and geoengineering), the consideration of justice is crucial (Audet, 2013; Lyster, 2017; Minguet, 2018; Okereke, 2010; Routledge et al., 2018). High endorsement for the message that climate change is a question of social justice indicates that the core message of the MOOCs has been successfully conveyed to the students. These learning outcomes are reinforced by the fact that participation in the MOOCs motivated participants to join other MOOCs (or formal courses at UAb; Coelho et al., 2015) in the future and to engage further with the topic of climate change. In summary, participating in either of the MOOCs improved the participants'

Table 6

Self-assessed competencies for participating critically in climate change debates.

After having completed the course, I am able to:			
Critically scrutinise the discussion about climate change in the media			
	Fern	UAb	
Mean	4.44	4.57	
fully agree (5)	44	57	
rather agree (4)	47	43	
neither agree nor disagree (3)	8	0	
rather disagree (2)	0	0	
fully disagree (1)	0	0	
Explain to others how climate change and social justice are closely interlinked			
	Fern	UAb	
Mean	4.53	4.62	
fully agree (5)	55	60	
rather agree (4)	37	37	
neither agree nor disagree (3)	7	3	
rather disagree (2)	0	0	
fully disagree (1)	1	0	
Engage in debates about climate change with persons from different backgrounds			
	Fern	UAb	
Mean	4.47	4.43	
fully agree (5)	51	49	
rather agree (4)	37	40	
neither agree nor disagree (3)	9	11	
rather disagree (2)	2	0	
fully disagree (1)	1	0	

Table 7

Participants' satisfaction with the course and outlook on further engagement in climate change issues.

I would like to participate in other MOOCs after my experience with this MOOC			
	Fern	UAb	
Yes	93	100	
No	1	0	
Overall, I would recommend the MOOC to others			
	Fern	UAb	
fully agree (5)	81	83	
rather agree (4)	17	14	
neither agree nor disagree (3)	2	3	
rather disagree (2)	0	0	
fully disagree (1)	0	0	
I would like to further occupy myself with the topic of climate change			
	Fern	UAb	
fully agree (5)	81	89	
rather agree (4)	16	28	
neither agree nor disagree (3)	3	3	
rather disagree (2)	0	0	
fully disagree (1)	0	0	

interdisciplinary knowledge and competencies to deal with the topic of climate change.

Despite these positive outcomes, the data gathered through the questionnaire implies that both MOOCs neither accomplished to entice a significant amount of participants from outside the higher education system nor those with a low pre-knowledge about climate change. Most likely, both findings go hand in hand with each other. Interestingly, especially those with a first academic degree and those who were already familiar with the topic of climate change achieved significant knowledge enhancements from their participation. The high learning satisfaction of the participants gives reason to believe that the learning experience was not only appreciated and considered as valuable but also spurred participants to enrol in other MOOCs and delve deeper into the topic of climate change.

A second glance at the data also revealed some clear limitations to these findings. First and foremost, and as highlighted before, the results face a survival bias as only those students that finished the course participated in the evaluation. Participants who got lost on the way through the MOOC might have had a different judgment. Referring to the low completion rate and the high number of registrations, it must be stated that the MOOCs have not educated massive amounts of participants. The problem of high dropout rates is widely known among MOOC providers who all suffer from low completion rates (see for example [Diver and Martinez, 2015](#); [Jordan, 2015](#)). However, research has shown that many widely-quoted dropout rates are calculated from baseline numbers which include registrations by people who never engage with the course or who engage in their own way but without completing assessments ([Onah et al., 2014](#)). Moreover, the correlation between dropout and learning failure in MOOCs is false as it is based on the wrong assumption that formal learning concepts apply to informal

learning contexts. For a subjectively successful learning experience, a learner does not necessarily need to fully complete a pre-determined learning path ([DeBoer et al., 2014](#); [Gütl et al., 2014](#)). Many participants who may be classified as dropouts, as the ones who do not complete the necessary components to gain a certificate, are still participating in the courses following their own different pace or with selective engagement ([Coelho et al., 2015](#); [Onah et al., 2014](#)). In fact, the term dropout in the context of MOOCs might need rephrasing ([Margaryan et al., 2014](#)). Dropout in a MOOC need not necessarily be synonymous with failure. This negative definition appears to be appropriate for university courses where grade and certification are a precondition to complete the study program. In MOOCs, a critical mass might never have intended to finish the course.

There is still a long discussion about MOOCs' instructional design quality that is often perceived as low ([Margaryan et al., 2014](#)). Most of the available MOOCs are designed by traditional universities that are not used to or do not have educational practice with distance learning. The MOOC case studies presented here were developed by well-established distance learning universities that used several instructional measures and activities, instead of creating a simple repository of educational resources. MOOCs can be used effectively to support existing learning and instruction, but as stand-alone environments, they fall short unless they have learning guidance, formative feedback, and overall assessment ([Coelho et al., 2015](#)).

As mentioned earlier, the FernUniversität-MOOC was based on an xMOOC approach and the UAb MOOC was based on a hybrid model which incorporates elements from existing MOOCs but adds other features drawn from UAb's experience with online learning. Both used well-validated written educational resources, experienced lecturers, collaborative tools and learning guidance to help

the participants in their learning processes. These circumstances may explain the similarities and responses of both MOOC participants.

The problem of the survival bias in the data likewise applies to the level of satisfaction with the MOOC. Potentially unsatisfied participants and those who had withdrawn due to personal circumstances were not part of the survey and do therefore not show up in the data. In addition, the results of the competency-based evaluation are subject to methodological restrictions. With the methodological approach used, we were only able to assess the students' self-perception of their learning success. These perceptions were not verified with a formal test or a written assignment. Still, using self-perception as an indicator of learning is a well-established method in social science (Dochy et al., 1999).

A second inconsistency is the stark educational disparity that occurs among the participants regarding those with a first or second degree and those without any educational background. The average level of education in both MOOCs is, however, far above the ordinary percentage of people with an academic degree in and outside OECD countries (OECD, 2017). This phenomenon of teaching the circles of the educated ones is best described by what we know as the Matthew effect (Merton, 1968). Persons, who had already been aware of climate change or deal with the issue in their professional lives, evidently enhanced their knowledge and competencies. People outside the educational system and those with limited pre-knowledge, who theoretically are supposed to benefit the most from open education and MOOCs, are omitted. MOOCs may pledge to provide open education, but this study disclosed no convincing evidence that the MOOCs have delivered on that promise. This contradiction disclosed here is reinforced by larger studies detecting that "the prior educational standard among MOOC students across the world far exceeds that of the general population in their own countries" (Emanuel, 2013, p. 342).

5. Conclusion

For this research, an exploratory evaluation was performed to disclose whether MOOCs, as a new and highly disputed educational tool for open education, can empower people to critical thinking about the challenging problems of climate change. It was argued that MOOCs can have a multiplier effect on climate change education, a puzzling field where public awareness and education is seen as a crucial precondition for individual and collective action. Two MOOCs offered by two experienced European distance learning universities were analysed and compared as case studies to gain valuable insights into the participants learning.

The findings of the evaluation demonstrate that almost all participants of both MOOCs have increased their level of knowledge and honed their competencies. Although the students already had a high pre-knowledge about climate change, the course still accomplished to increase their knowledge. Furthermore, they would like to further occupy themselves with the topic of climate change. These outcomes, at first sight, support the conviction that MOOCs hold the potential to be a powerful tool that can empower people to critical climate thinking. However, the in-depth analysis of the evaluation has revealed some noteworthy limitations to relativize the impact of MOOCs on climate change education. These limitations admonish us not to join into the hymn of praise about MOOCs without any reservations. While learning success was observed in the participants' self-evaluations, there is an imbalance occurring regarding the question of *who* is actually learning: The educational level of the participants in the MOOCs by far exceeds the mean education level in western countries.

The MOOCs did not attract a significant amount of participants without an academic degree. This is concerning because

participation of lay people in open education about climate change would be required to raise public awareness and lead to climate change literacy and action among bigger parts of the population.

Second, methodological restrictions do only allow for ascertaining knowledge and competency development based on the students' self-perception. However, this knowledge and competency development in the two cases goes hand in hand with learning satisfaction and the successful attaining of a MOOC certificate.

In a nutshell, a more differentiated view on MOOCs and their learning potential should be adopted. To this end, future research could apply more qualitative evaluations to analyse in depth the individual learning motivation of the participants and the use of MOOCs in the respective learning context. In the case of climate change, one option for the further development of MOOCs would be to think of better ways of how to integrate them into climate change education, for example in educational work or campaigning. This might establish a new target group for MOOCs. Another option is to consider possibilities to increase the attractiveness of MOOCs for instance by using innovative formats and thereby to overcome the barriers between formal and informal learning of the participants.

In summary, this research sheds light on the still ongoing debate about MOOCs as a tool for learning about topics of sustainable development. As the findings indicate, MOOCs are able to convey certain learning outcomes to the students and thus can contribute to climate change literacy. Determining the quality of the participants' learning outcomes and strategies for the expansion of the target group for MOOCs about climate change, however, needs further research.

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